The Other Half of the Problem – Server Closets and Small Server Rooms

Bill Tschudi

Lawrence Berkeley National Laboratory

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wftschudi@lbl.gov

Bay Area Digital Government Summit

BERKELEY LAB
Lawrence Berkeley National Laboratory

Our study involved a collaboration

BERKELEY LAB
Lawrence Berkeley National Laboratory

STANFORD
UNIVERSITY

NRDC
THE EARTH'S BEST DEFENSE

Study focused on small spaces

'Small Server Rooms'

Type	Server Closet	Server Room	Localized Data Center	Mid-tier Data Center	Enterprise-Class Data Center
Scope	Secondary computer location, often outside of IT control, or may be a primary site for a small business	Secondary computer location, under IT control, or may be a primary site for a small business	Primary or secondary computer location, under IT control	Primary computing location, under IT control	Primary computing location, under IT control
[illegible]	[illegible]	[illegible]ed room [illegible]itioning, single UPS	Maintained at 17°C; some power and cooling redundancy	Maintained at 17°C; some power and cooling redundancy	Maintained at 17°C; at least N+1 power & cooling redundancy
Applications	Point-specific applications	Departmental or point-specific applications	Some enterprisewide applications, business critical	Some enterprisewide applications, business critical	Enterprisewide applications, mission critical
Sq ft	<200sq ft	<500sq ft	<1,000sq ft	<5,000sq ft	>5,000 sq ft
Response to downtime	Within one day	Within four hours	Within two hours	Within minutes; may have hot site for redundancy	Immediate; has hot site for redundancy
US data centers (2009 est)	1,345,741	1,170,399	64,229	9,758	7,006
Total Servers (2009 est)	2,135,538	3,057,834	2,107,592	1,869,595	3,604,678
Average servers per location	2	3	32	192	515

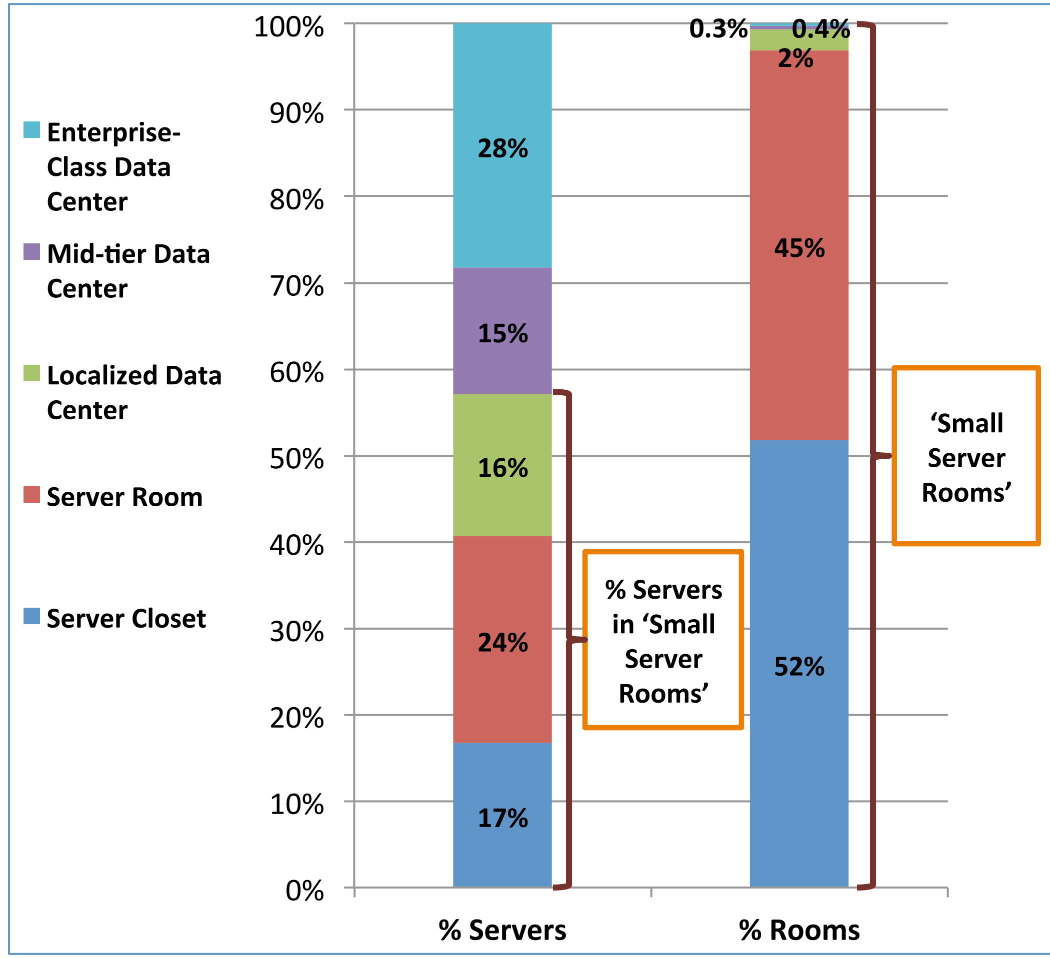
Source: IDC Special Study, Data Center of the Future, Michelle Bailey, et. al. Filing Information: April 2006, IDC #06C4799

57% of Servers in 99.3% of Server Rooms

('Small Server Rooms')

2.5 million 'server rooms'

Many configurations



Source: EPRI Analysis of IDC Special Study, Data Center of the Future

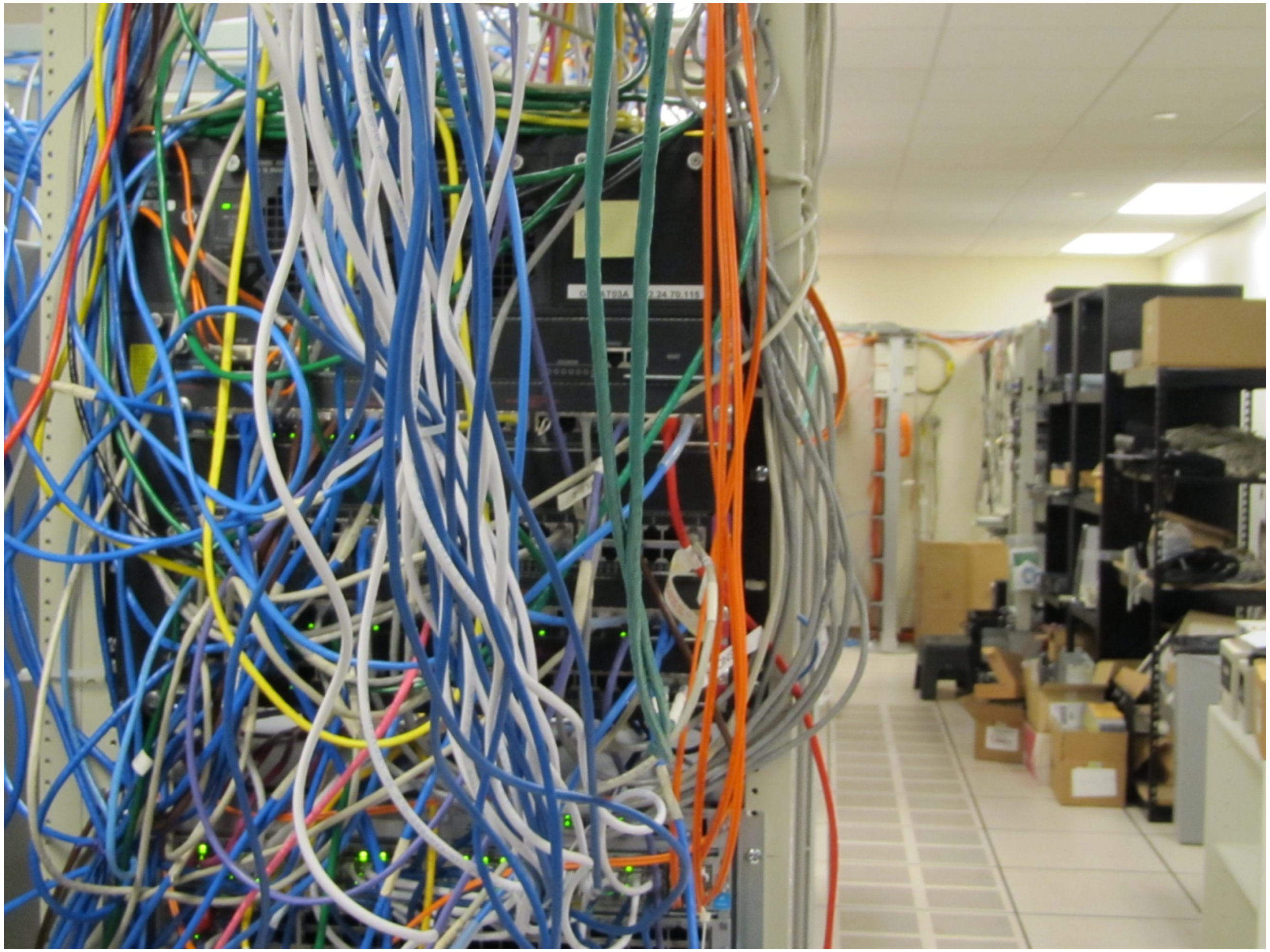
The LBNL study characterized IT equipment and how it was powered and cooled

Walkthrough assessments confirmed variety of configurations

Detailed investigation of four spaces

Efficiency measures identified

We examined a number of server spaces



LBNL, Stanford University, a hospital, two city governments, a major corporation, and a small business

We found some common themes

ENVIRONMENTAL ENERGY TECHNOLOGIES DIVISION FACT SHEET:

BERKELEY LAB

September 2012

Improving Energy Efficiency for Server Rooms and Closets

Top 14 Measures to Save Energy in Your Server Room or Closet

Introduction

Is there a ghost in your IT closet? If your building has one or more IT rooms or closets containing between 5 and 50 servers, chances are that they account for a significant share of the building's energy use (in some cases, over half!). Servers, data storage arrays, networking equipment, and the cooling and power conditioning that support them tend to draw large amounts of energy 24/7, in many cases using more energy annually than traditional building loads such as HVAC and lighting.

The good news is that there are many cost-effective actions, ranging from simple to advanced, that can dramatically reduce that energy use, helping you to save money and reduce pollution.

A. Simplest, No-Cost, or Very-Low-Cost Measures

1 Determine computational functions/Turn off any unused servers

An Uptime Institute survey suggests that close to 30% of servers in data centers are consuming power but not doing any useful work. To better manage server usage and utilization, create and regularly update a server hardware and application inventory that will help you track the number of applications running on each server. Mapping applications to the physical servers on which they are running helps identify unused servers and opportunities for consolidation. Just make sure to migrate any remaining data or workloads before shutting down.

2 Increase temperature setpoints to the high end of ASHRAE's recommended limit

ASHRAE temperature guidelines allow much broader operating ranges than those commonly used, allowing the air temperature at the IT equipment inlet to be raised—up to 80°F or higher—which considerably reduces cooling energy usage.

3 Examine power backup requirements (do you really need UPS equipment, and if so, how much is enough?)

Many IT applications are not so critical that they cannot be shut down if there is a power disturbance and restarted without adverse effects. Analyzing your power backup requirements can help you eliminate capital costs for unnecessary or oversized redundant power supplies or Uninterruptible Power Supply (UPS) equipment. It can also help you save energy lost in power conversion in those devices as well as energy used to cool them. Anything that needs high reliability should be a candidate for moving to a true data center or cloud solution.

4 Airflow management: Install blanking panels and block holes between servers in racks

Airflow management is conceptually simple and surprisingly easy to implement. Your challenge: ensuring that the cool air from your cooling equipment gets to the inlet of your IT gear, without getting mixed with the hot air coming from the back; and ensuring that hot air going back to the cooling equipment does not mix with the cold air. This can be done by clearing clutter from the airflow path, blanking within and between the racks and the openings in the floor if the gear sits on a raised floor. Containment of cold or hot aisles is a more effective approach. When good airflow management is in place, further savings can be realized through additional measures, such as raising temperature setpoints.

B. A little More Complex, But Still Fairly Simple

5 Refresh the oldest equipment with high-efficiency models

Establish server refresh policies that account for increases in generation-on-generation computational ability, energy-efficiency, and power manageability improvements. The savings in energy and software costs will often justify a faster refresh than expected. Consider Energy Star, Climate Savers Computing Initiative Server Catalog, high-temperature tolerant servers, and high-efficiency power supplies (80 PLUS®). When purchasing new equipment, servers with solid-state drives (SSD), rather than hard disk drives, may be considered, as they feature faster speeds, are generally considered to be more reliable, and consume less power.

6 Move to a more energy-efficient internal or external data center space, or to cloud solutions

Distributed server rooms are typically not very energy efficient. If a central data center is available, you may be able to save energy and reduce your utility bill, by moving your servers to that location. When a data center is not available, many organizations are moving their equipment to co-location or cloud facilities (public or private cloud facilities both typically provide much better efficiencies than on-premise server rooms). Data centers, colocation and cloud facilities typically offer better security, redundancy, and efficiency than is usually available in server rooms.

7 Energy-efficiency awareness training for IT custodial and facility staff

Have your IT and facilities staff attend server room energy-efficiency awareness classes offered by utility companies, ASHRAE, and other efficiency advocates, to take full advantage of best practices in that area.

C. More Complex, But Very Cost-Effective

8 Implement server power management

Check for power management options that come with your server models and enable power management if possible. Power management saves energy, especially for applications that do not run continuously or are accessed infrequently. Power cycling can also be implemented to put servers that are unused for long periods of time in a light sleep mode. Lastly, consider built-in or add-in cards that enable to power servers on or off remotely when they are not in use.

9 Consolidate and virtualize applications

Typical servers in server rooms and closets run at very low utilization levels (5-15% on average), while drawing 60-90% of their peak power. Consolidating multiple applications on a smaller number of servers accomplishes the same amount of computational work, with the same level of performance, with much lower energy consumption. Virtualization is a proven method for consolidating applications, allowing multiple applications to run in their own environments on shared servers. By increasing server utilization, this reduces both the number of servers required to run a given number of applications and overall server energy use.

10 Implement rack/infrastructure power monitoring

Power monitoring identifies the energy use and efficiencies of the various components in an electrical distribution system. Power meters can be installed at the panels serving the cooling units, or directly on IT and HVAC equipment. Another alternative is to read IT power from UPS display, and to estimate cooling power from the nameplate, taking into account unit efficiency and operating hours. Often power distribution products will have built-in monitoring capability. A key metric is the Power Usage Effectiveness (PUE), which is the ratio of total power to IT input power (with the "overhead" being electrical distribution losses plus cooling power usage). Monitor and strive to lower your PUE: over 2 shows significant room for improvement; 1.5 is good; 1.1 is excellent.

11 Install variable frequency drives on cooling units

If your server room is cooled with a Computer-Room Air Handler (CRAH) or Computer-Room Air Conditioner (CRAC) unit, then it is highly likely that the unit has a single-speed fan, and that it provides more airflow than your IT equipment needs. Units with variable frequency drives (VFDs) have the capability of providing only the amount of air that is required by the IT equipment. To maximize potential energy savings, coordinate the implementation of airflow management measures and airflow isolation systems with the installation of a VFD on the cooling unit fan. See item 4 for air management suggestions. Ideally the fan speed should be dynamically controlled to maintain IT inlet temperature within the recommended range.

12 Install rack- and row-level cooling

If you are installing a new server room or buying new racks, consider local cooling; in?rack and in-row cooling refer to a cooling system located in that rack or row. Another highly efficient option is a Rear Door Heat Exchanger (RDHX), in which a coil is installed directly on the rear (exhaust) section of the server rack. Condenser (Tower) water, chilled water, or refrigerant is run through the coils to passively absorb the exhaust heat and provide the needed cooling. Air circulation through the cooling coil is provided by the internal server fans.

13 Use economizers: air-side economizers

An economizer simply draws in outside air for cooling when conditions are suitable. For a server closet with exterior walls or roof, there is a good possibility that an air-side economizer could be installed. This could be in the form of an exhaust fan removing heat in one portion of the room and an opening in another location allowing cool, outside air to enter; or it could be in the form of a fan coil or CRAC/H with air-side economizer capability. Depending on the climate zone in which the server closet is located, this strategy can save a significant amount of energy by reducing compressor cooling energy use.

14 Install dedicated cooling for the room, rather than depending on building cooling

Install cooling equipment solely for the use of the room, so that the building system does not have to operate around the clock. If a retrofit is in order, installing dedicated cooling equipment (like a packaged air conditioning unit) for your server room(s) can result in signivvnt energy savings. Specify a high-efficiency unit with a high SEER rating.

For information on how to implement each of these actions, refer to:

url

url

Or, contact:

Richard Brown
REBrown@lbl.gov

William Tschudi
WFTschudi@lbl.gov

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http://hightech.lbl.gov/serverclosets

Low cost measures can get the ball rolling

Asset inventory of applications and IT equipment/ shut off unneeded devices

Adjust temperatures to meet industry guidelines

Review whether back-up power is needed

There is a lot of misunderstanding of environmental conditions needed for IT equipment

Microsoft operated computers in a tent for 8 months with no failures

If you walk into a server closet and it is cold… there is an energy efficiency opportunity

Environmental

Temperature:
- Operating: 10° to 35°C (50° to 95°F)
- Storage: -40° to 65°C (-40° to 149°F)

Relative humidity
- Operating: 20% to 80% (non-condensing)
- Storage: 5% to 95% (non-condensing)

Altitude
- Operating: -15 to 3048 m (-50 to 10,000 ft)
- Storage: -15 to 10,668 m (-50 to 35,000 ft)

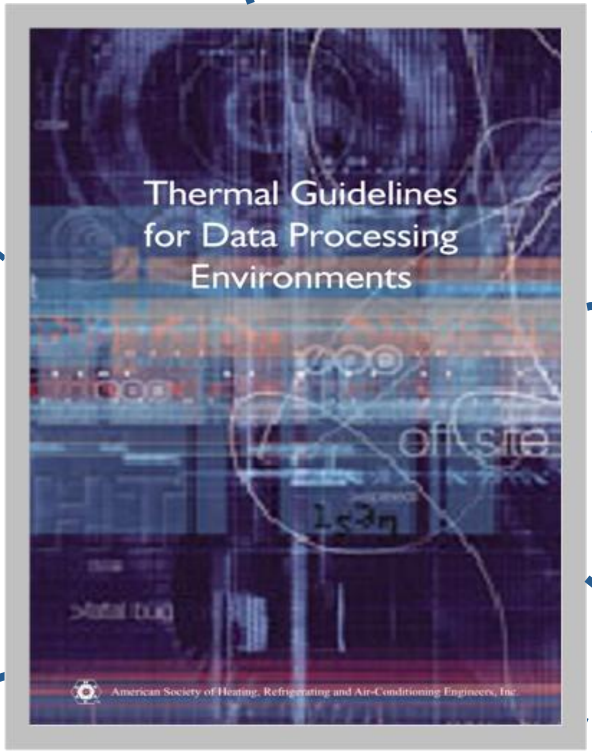
The industry has moved on - IT equipment operates reliably at higher temperatures.

ASHRAE Thermal Guidelines are the defacto standard in the industry

Provides common understanding between IT and facility staff.

"Recommended" temperature range up to 80.6°F with "allowable" much higher.

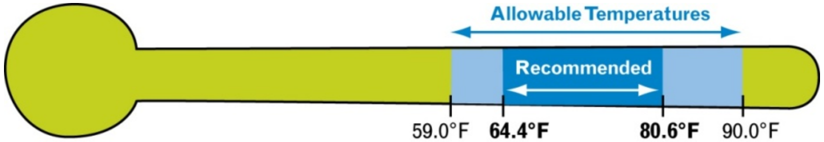
Developed with IT manufacturers



Six classes of equipment identified with wider allowable ranges to 45° C (113°F).

Provides more justification for operating above the recommended limits

Provides wider humidity ranges



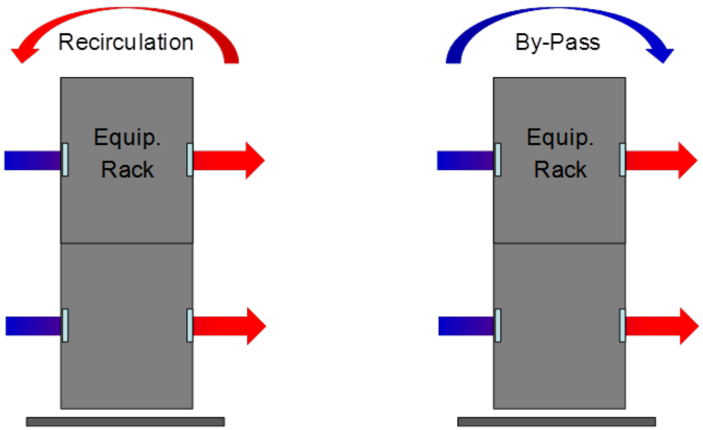
ASHRAE Thermal Guidelines

Classes (a)	Equipment Environmental Specifications							
	Product Operations (b)(c)					Product Power Off (c) (d)		
	Dry-Bulb Temperature (°F) (e) (g)	Humidity Range, non-Condensing (h) (i)	Maximum Dew Point (°F)	Maximum Elevation (f)	Maximum Rate of Change(°F/hr) (f)	Dry-Bulb Temperature (°F)	Relative Humidity (%)	Maximum Dew Point (°F)
Recommended (Applies to all A classes; individual data centers can choose to expand this range based upon the analysis described in this document)								
A1 to A4	64.4 to 80.6	41.9°F DP to 60% RH and 59°F DP						
Allowable								
A1	59 to 89.6	20 to 80% RH	62.6	10,000	9/36	41 to 113	8 to 80	80.6
A2	50 to 95	20 to 80% RH	69.8	10,000	9/36	41 to 113	8 to 80	80.6
A3	41 to 104	10.4°F DP & 8% RH to 85% RH	75.2	10,000	9/36	41 to 113	8 to 85	80.6
A4	41 to 113	10.4°F DP & 8% RH to 90% RH	75.2	10,000	9/36	41 to 113	8 to 90	80.6
B	41 to 95	8% RH to 80% RH	82.4	10,000	NA	41 to 113	8 to 80	84.2
C	41 to 104	8% RH to 80% RH	82.4	10,000	NA	41 to 113	8 to 80	84.2

Note that recommended range goes to 80°F and allowable is much higher

Additional measures can pay off

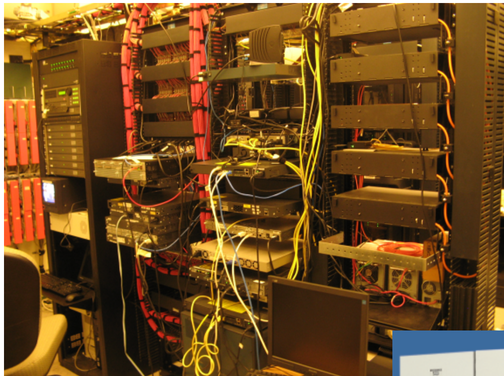
Refresh with modern equipment
virtualize and consolidate
enable power management



Air management – eliminate air bypass and recirculation

Move to well managed data center or cloud

We found more opportunities for one well-organized city government as a result of detailed evaluations.

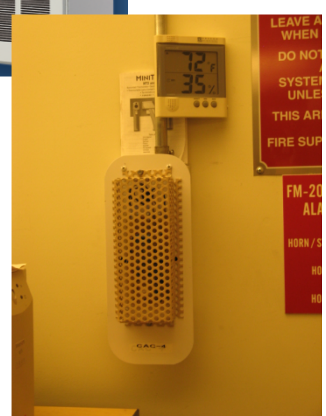


IT opportunity:

- Refresh with equipment using ASHRAE environmental conditions

Electrical opportunity:

- Put UPS in bypass mode -



Cooling opportunities:

- Replace rooftop units and use free cooling
- Eliminate humidification
- 80% savings in HVAC

Current PUE = 2.1
Possible PUE = 1.2

At LBNL, we found many of the same opportunities in our own spaces.

IT opportunities:

- Retire unused machines that are still turned on
- Virtualize and consolidate
- Provide organizational incentives to share IT resources and to move to centralized IT management

Current PUE = 1.5
Possible PUE = 1.2

Cooling opportunities:

- Temperature control and economizer mode for window air conditioners
- Better airflow management (hot and cold air discharged into the same space)

Barriers to Energy Efficiency

Financial Disincentives

- Budget authority lies elsewhere
- Power bill paid by others
- Individual measures result in small savings
- Moving to a cloud service is a different financial paradigm

Concerns/Misconceptions

- Need for constant access
- Access = Security
- Fear of response time if there is a problem

Organizational

- Lack of central organizational policies for server management
- Moving an operating server requires coordination
- Research funding mechanism & equipment management

There is a knowledge void or even misinformation in many areas:

- Environmental conditions
- Need for back up power and redundancy
- Virtualization
- Power management in IT equipment
- Cooling options
- Power conversion – efficiency of UPS and power supply
- Cloud options

Training in these and other topics would help drive efficiency improvement

Efficiency Opportunities

IT

- Refresh IT equipment
- Server Power Management
- Application mapping (turning off unused servers)
- Server Consolidation
- Virtualization
- Move to the Cloud
- Move to Central Datacenter
- High temperature tolerant hardware
- Efficient Power Supplies/ redundancy

Electrical

- Optimize redundancy
- Highly efficient UPS, transformers
- Power monitoring of IT and Cooling equipment
- Lighting controls

Cooling

- Air flow management: Containment, Cable Cleanup
- Cooling improvements: building systems, rack or row cooling, VFDs, reduced compressor based cooling
- Outdoor air cooling
- Air at IT equipment inlet meeting ASHRAE 2011 recommendations
- Beneficial use of server heat
- Link cooling control to BMS

Free up power, cooling and space for other use

Center of Expertise for Data Centers

Coming Soon

Resources

Federal Programs

Federal Energy Management Program (FEMP)

- Assessment tools
- Data Center Energy Practitioner Program
- Data Center Challenge
- Industry Projections
- Measure and monitor
- Case studies

General Services Administration (GSA)

Environmental Protection Agency (EPA)

- Energy Star Buildings
- Energy Star Products

Federal Data Center Consolidation Initiative

Industry Organizations

The Green Grid

ASHRAE

7 X 24 Exchange

Uptime Institute

AFCOM

ITIC

Silicon Valley Leadership Group

Critical Facilities Roundtable

In summary, there are many improvements that can be made to pursue the "other half".

Awareness training can have a large impact

Organizations need policies to control server sprawl

Utility incentives can help cost justify specific opportunities

UPS room cooling

Questions?

Resources - websites

http://hightech.lbl.gov/datacenters.html
http://hightech.lbl.gov/serverclosets.htm

http://www1.eere.energy.gov/femp/program/data_center.html

http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

U.S. Department of
ENERGY

http://www1.eere.energy.gov/manufacturing/datacenters/